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INSTRUCTION REPORT S-77-2

HEATER-PLANER, HEATER-SCARIFIER, AND HEATER-REMIX-OVERLAY MAINTENANCE PROCEDURES FOR BITUMINOUS PAVEMENTS

by

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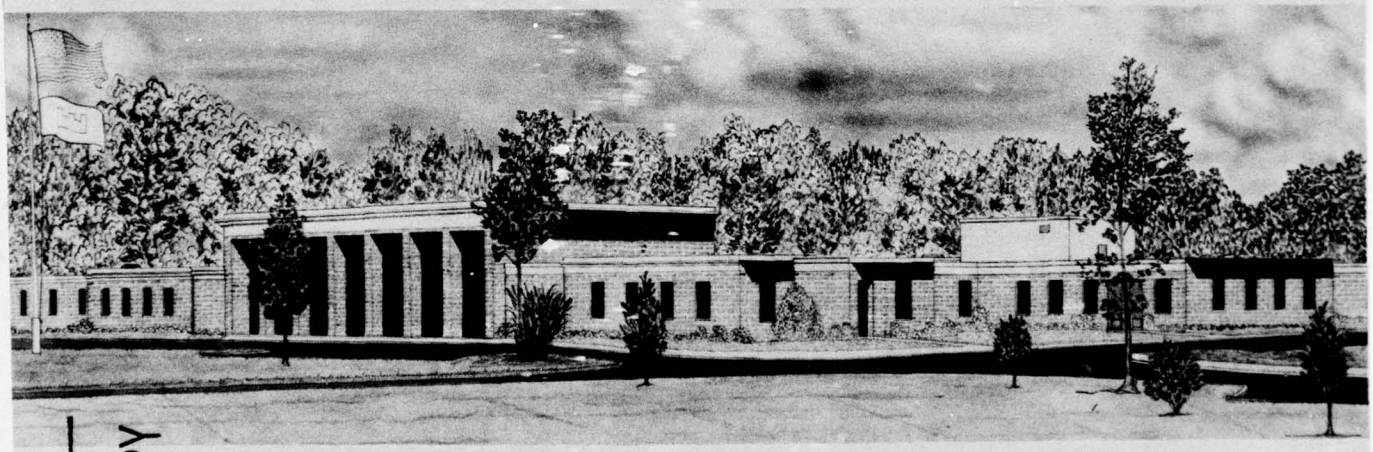
Final Report



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20. ABSTRACT *(Continue on reverse side if necessary and identify by block number)*

This report was prepared to provide information and guidance concerning maintenance and repair techniques of bituminous pavements. This report discusses construction procedures, equipment, and applications for pavement maintenance using heater-planers, heater-scarifiers, and heater-repavers. Recommended guide specifications are presented herein.

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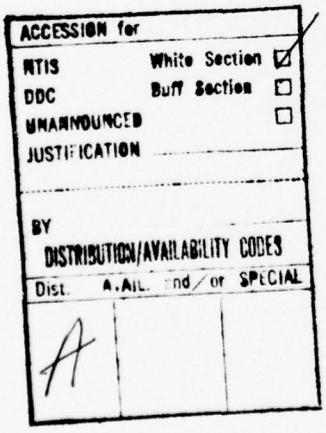
PREFACE

The preparation of this report was authorized by O&MA Project No. 4K078012AQ61, Task 04, Work Unit 009.

The report was compiled under the general supervision of Messrs. J. P. Sale, R. G. Ahlvin, and R. L. Hutchinson, Chief, Assistant Chief, and Pavement Program Manager, respectively, of the Soils and Pavements Laboratory, U. S. Army Engineer Waterways Experiment Station (WES). Engineers of the Soils and Pavements Laboratory actively engaged in the planning, data collecting, testing, analysis, and reporting phases of the study were Messrs. A. H. Joseph, C. D. Burns, and R. W. Grau. This report was written by Mr. Grau.

COL G. H. Hilt, CE, and COL J. L. Cannon, CE, were Directors of WES during the preparation and publication of this report. Mr. F. R. Brown was Technical Director.



CONTENTS

CONVERSION FACTORS, U. S. CUSTOMARY TO METRIC (SI)

UNITS OF MEASUREMENT

U. S. customary units of measurement used in this report can be converted to metric (SI) units as follows:

Multiply	By	To Obtain
inches	25.4	millimetres
feet	0.3048	metres
square yards	0.8361274	square metres
feet per minute	0.3048	metres per minute
gallons (U. S. liquid)	3.785412	cubic decimetres
gallons (U. S. liquid) per square yard	0.004527	cubic metres per square metre
pounds (force) per square inch	6894.757	pascals
tons (2000 lb mass)	907.1847	kilograms
pounds (mass)	0.4535924	kilograms
Fahrenheit degrees	5/9	Celsius degrees or Kelvins*

* To obtain Celsius (C) temperature readings from Fahrenheit (F) readings, use the following formula: $C = (5/9)(F - 32)$. To obtain Kelvin (K) readings, use: $K = (5/9)(F - 32) + 273.15$.

HEATER-PLANER, HEATER-SCARIFIER, AND HEATER-REMIX-OVERLAY MAINTENANCE PROCEDURES FOR BITUMINOUS PAVEMENTS

PART I: INTRODUCTION

Background

1. Until recently, the maintenance of bituminous pavements has been accomplished almost exclusively by using virgin select materials. However, due to the high cost of aggregate, asphalt, and the transporting of the materials, a growing interest in recycling or reclaiming pavements has developed. Heater-planing, heater-scarifying, and heater-remix-overlaying equipment and techniques have been developed in the past few years for the repair of surface defects or grade irregularities in bituminous pavements.

2. In the late 1950's, the heater-planer process for maintenance of bituminous pavements was developed. This process was used for removal of excess bituminous materials in order to maintain grade for overlays and for leveling an uneven pavement surface. Modifications in the burners and equipment have been made over the years. At the present time, the heating systems are fueled with either propane or butane instead of diesel which created a smoke problem. Other modifications in the heating process, such as use of radiant heat and improved controls on open-flame burners, have minimized the air pollution problem caused by earlier models which burned the pavement. In recent years, a heater-remix-overlay process has been developed in which, in addition to heating and leveling of the existing pavement, the pavement is scarified and overlaid with a thin layer of new mix. A rejuvenating agent can be added to the existing mix during this process if desired. One commercially available machine has the capability of performing the heater-remix-overlay process in one operation. With other heater-remix-overlay operations, several pieces of equipment are used in a train.

Purpose

3. The intent of this report is to provide information and guidance concerning maintenance and repair techniques for bituminous pavements, thus assuring the Army full use of existing pavements at minimum cost. Specifically, this report discusses construction procedures, equipment, and applications for pavement maintenance using heater-planers, heater-repavers, and heater-scarifiers. A recommended guide specification is presented in Appendix A.

Environmental and Economic Aspects

4. The maintenance and repair of asphaltic concrete pavements by using heater-planers, heater-scarifiers, or heater-repavers offer some environmental and economic advantages over conventional overlay methods. Reuse of old bituminous materials reclaimed during the heater-planing or heater-scarifying processes has a favorable and immediate environmental consequence in that both the demand for landfill disposal areas for waste material and the amount of new material needed for pavement maintenance are reduced. Initial cost savings have been reported[1] by users of these maintenance procedures, and long-term savings[2] have also been found to be appreciable due to the small amount of maintenance required in succeeding years. Initial cost savings are a result of the reduced amount of new mix required as compared to the conventional overlay procedure because the need of a leveling course is eliminated and less new mix is required for a wearing surface. A savings in fuel is also realized from the decreased demand for new mix and from the associated transportation requirements. Costs involved in adjusting manholes, storm sewer inlets, valve boxes, etc., are also less as compared to those associated with conventional overlays. Although the above data indicate that it is economically advantageous to use heater-planer, heater-scarifier, or heater-repaver procedures for maintaining pavements, it should be noted that the initial savings will vary considerably depending on such factors as the size of the project and the availability of new materials and that a direct cost comparison

relative to conventional overlay methods can be misleading due to their different objectives. Conventional resurfacing is often required to add structural strength to a pavement in addition to improving its rideability, whereas these other procedures are primarily a surface treatment.

PART II: DESCRIPTION OF EQUIPMENT AND PROCEDURES

Equipment

Heater-planers

5. Heater-planers generally all operate on the same principle but vary considerably in design and appearance as shown in Figures 1 and 2. The basic components of a heater-planer are the heating system and the planing mechanism. Heating systems consist of either radiant emitters or open-flame burners. These emitters or burners are enclosed by a hood which directs the heat onto the pavement surface. The planing mechanism is made up of steel diagonal blades in the form of a "v" located directly behind the heating unit. These planing blades cut, level, and gather the heated mix into a windrow for loading. Units are now equipped with an elevator which continuously picks up the windrowed mix and conveys it to a dump truck. Some heater-planer units have the capability to loosen and process the heated pavement with a scarifying mechanism prior to the planing operation. Other options include automatic controls or a spring tension device to relieve overloads and to protect manholes and valve structures from damage.

6. Heater-planers operate at working speeds ranging from 5 to 70 ft/min* and for a depth of 1/4 to 3/4 in. depending upon the depth of heating and type of pavement. The maximum width of the planing mechanism is 8 ft. The temperature of the windrowed material immediately after planing ranges between 180 and 240°F.

Heater-scarifiers and repavers

7. The heater-scarifier or repaving process generally includes heating, scarifying, adding a rejuvenator agent to the recycled mix, and then overlaying the recycled mix with a thin layer of new mix. If a rejuvenator is required, it is either applied as a tack coat or directly to the mix during the recycling process. Basically, there are two different procedures used for this type of maintenance process depending upon the

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* A table of factors for converting U. S. customary units of measurement to metric (SI) units is presented on page 3.

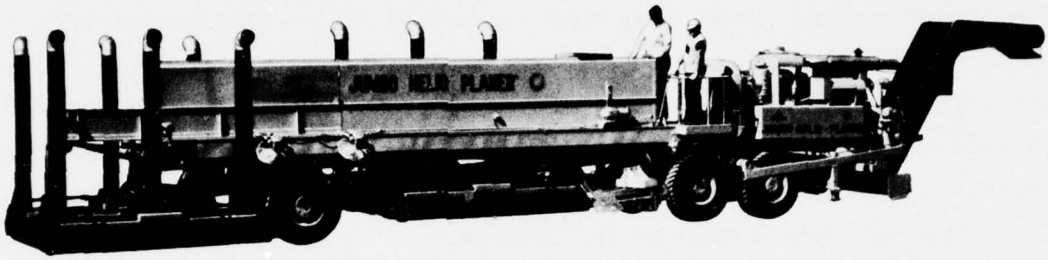

Figure 1. Bituminous pavement heater-planer

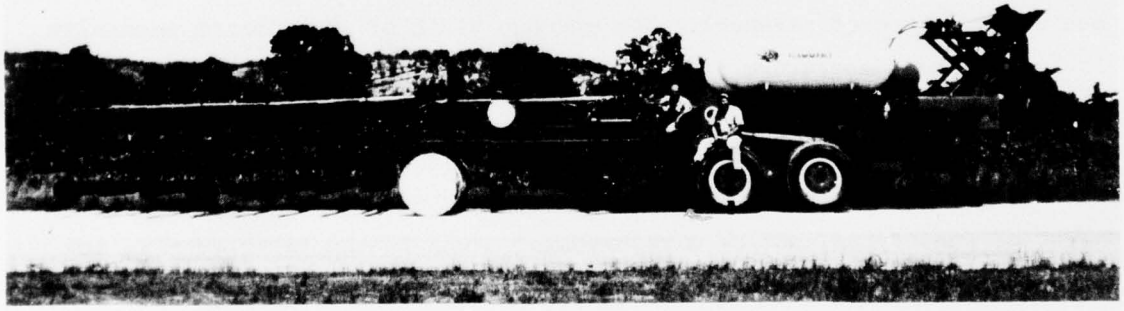

Figure 2. Bituminous pavement heater-planer

equipment. One procedure employs a train of equipment--heater-scarifiers, distributors, and paving machines--while the other procedure utilizes one machine capable of heating and remixing the upper portion of the old pavement and then placing a thin new overlay in one operation. The recycling equipment shown in Figures 3 through 5 are primarily heater-scarifiers. The uniformity and smoothness of the recycled surface material are dependent upon the design of the scarifier for the units shown in Figures 3 and 4 and upon an oscillating screed for the unit shown in Figure 5. Compaction equipment, a distributor, and a paving machine operating in tandem with these heater-scarifiers are required for the heater-remix-overlay process. The repaver shown in Figure 6 is a single-pass recycling and resurfacing machine. This machine was designed to heat and scarify the existing pavement to a depth of approximately 3/4 in., relay the reclaimed material to the desired grade, and place a thin overlay of new mix on the heated remixed material in one continuous operation. Initial compaction is obtained with the vibrator screed. Rolling is the only additional operation required with this repaver to complete the heater-remix-overlay process. Repavers are also capable of applying and mixing rejuvenators and/or virgin bituminous mix into the recycled pavement prior to placement. A set of leveling screws and a leveling blade positioned behind the scarifier assembly on the repaver level the recycled mix prior to application of the overlay.

8. Heater-scarifiers operate at widths up to 14 ft and at speeds ranging from 5 to 70 ft/min. The pavement is usually heated and scarified to a depth of 1/4 to 3/4 in. in one pass depending upon type of pavement and its temperature prior to treatment. Sufficient heat is applied to ensure a minimum temperature of 225°F for the remixed material after scarification and leveling. The repaver shown in Figure 6 was designed to heat, plane, and scarify to a depth of approximately 3/4 in. and to place a 3/4- to 1-1/4-in.-thick layer of virgin material in one pass at a rate of 8 to 25 ft/min. The maximum operating width of this machine is 9 ft. The heating units on the repaver and the speed of the machine are adjusted to ensure no burning of the scarified mix and a minimum temperature of 200°F prior to placement of the thin overlay.

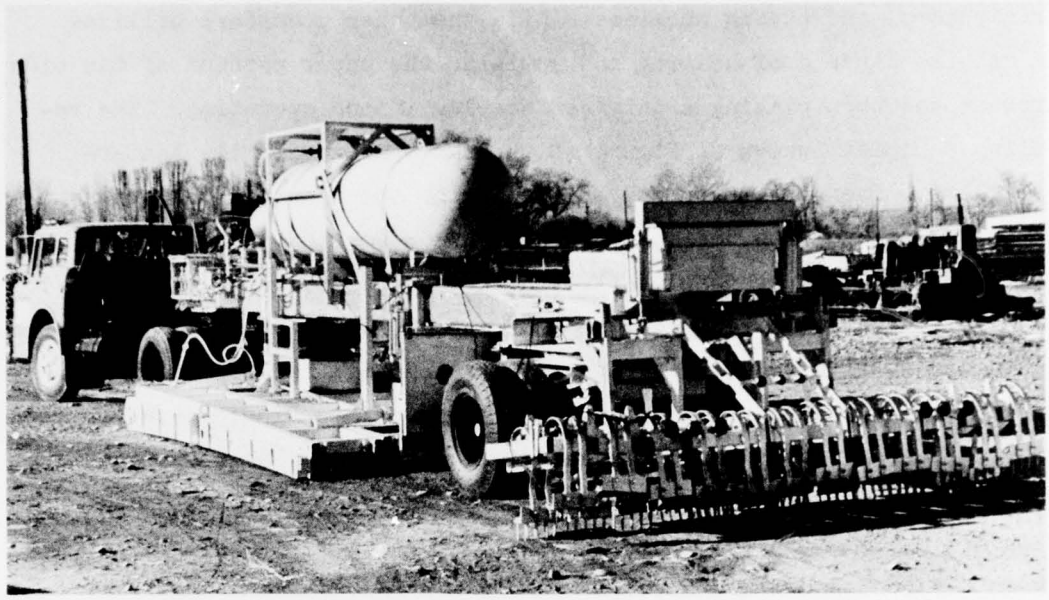

Figure 3. Bituminous pavement heater-scarifier

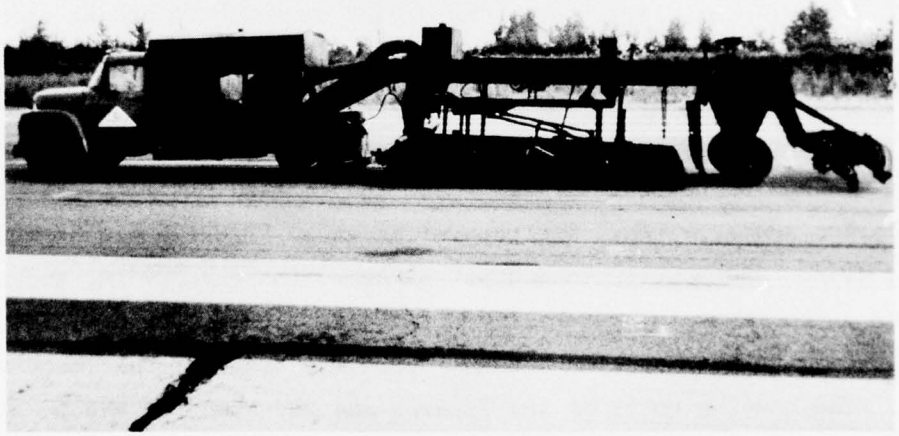

Figure 4. Bituminous pavement heater-scarifier

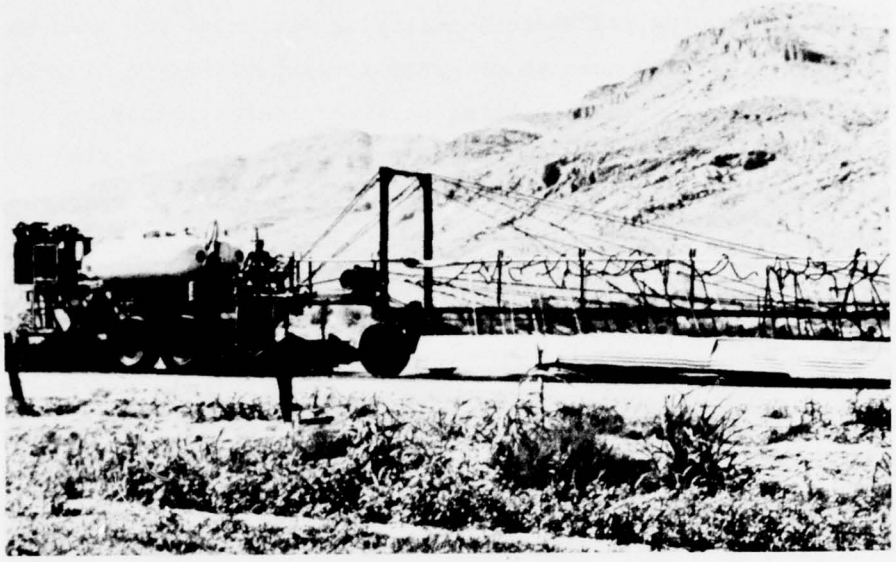

Figure 5. Bituminous pavement heater-scarifier

Figure 6. Bituminous pavement repaver

Construction Procedures

9. Heater-planing and heater-scarifying equipment are used to remove or correct surface defects or grade irregularities in bituminous pavements. However, the basic contingencies of heater-planer or heater-scarifier work are that the unsurfaced planed or scarified area will ravel badly and that some type of surfacing or seal is required. General construction procedures for correcting surface defects or grade irregularities in bituminous pavements are discussed in the following paragraphs.

Heater-planer operations

10. The flow chart shown in Figure 7 indicates the operations required to rehabilitate a bituminous pavement by the heater-planer method. After preparation of the area, this maintenance procedure is accomplished with a train of equipment consisting of a heater-planer or heater-scarifier and motor grader, a front-end loader if the planer or scarifier is not equipped with a self-loading elevator, dump trucks, a distributor, and compaction equipment. Preparation of the construction area consists of restoring drainage; replacing broken curb sections; repairing potholes, base failures, and any large cracks; and then removing dirt, water, and foreign material from the surface to be planed. A heater-planer unit then processes the pavement to the desired depth (multiple passes may be required) and windrows the cuttings to be picked up by a front-end loader or by a self-loading elevator. In some instances, a heater-scarifier is used to loosen the pavement, and a motor grader planes and windrows the material for removal. After the desired thickness has been removed or the irregularities have been eliminated, the planed surface is rolled to seat the loose particles, and then a rejuvenating agent may be applied to the surface. Final adjustments are made as required to manholes, sewer inlets, etc., and then the area is cleaned. The operating speeds of heater-planer and heater-scarifier units range between 5 and 70 ft/min; however, the rate to plane a pavement depends upon the condition of the pavement and the number of cuts or passes required to provide a smooth surface.

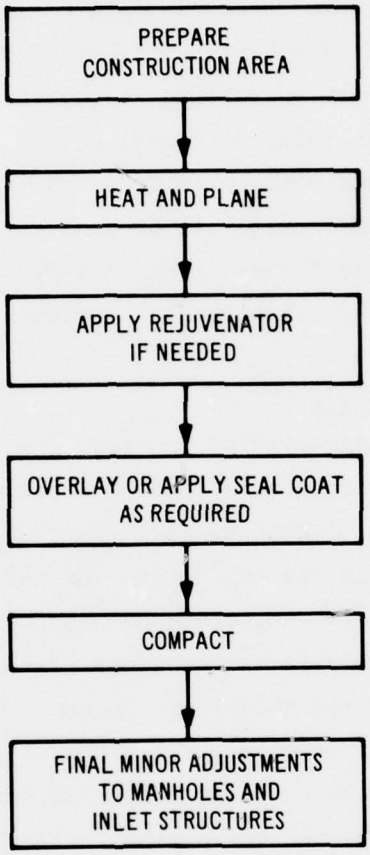

Figure 7. Process flow chart, heater-planer method

Heater-scarifier operations

11. The heater-scarifier procedure is a method of treating the surface of existing pavements to correct minor distortions, oxidized or cracked surfaces, or to restore skid resistance. This method consists of heating and scarifying the existing surface to a depth of approximately 3/4 in. and screeding the loosened material to the required contour and grade. After the scarified material has been spread to the desired grade and contour and prior to rolling, a rejuvenating agent may be added if the pavement was badly oxidized, or sand or larger coated aggregate may be added to restore the skid resistance of the pavement. A tandem steel-wheel roller should then be used for compaction. Heater-scarifiers are depicted in Figures 3 through 5. A flow chart indicating the operations required to rehabilitate a pavement by the heater-scarifier method is shown in Figure 8.

Heater-remix-overlay process

12. The heater-remix-overlay process is a method of treating existing pavements which creates a zone of reclaimed mix between the new overlay and the existing bituminous mix. This method consists of recycling and leveling approximately the top 3/4 in. of the existing pavement and then placing a 3/4- to 1-1/4-in.-thick overlay of new material. The flow chart shown in Figure 9 indicates the operations required to rehabilitate a pavement by the heater-remix-overlay process. With the exception of raising the elevations of manholes, valve boxes, etc., to correspond to the design grade of the new surface, the preparation of the area is the same as that for heater-planer operations. After area preparation, a train of equipment consisting of a distributor, heater-scarifier, paver, and roller is required to accomplish this process. Heating and scarifying the pavement to an approximate depth of 3/4 in. and leveling the reclaimed mix are performed with a heater-scarifier unit. A rejuvenator is then applied to the heated scarified mix. Immediately after leveling of the reclaimed mix and applying of the rejuvenator, if required, a paving machine places a thin overlay of new bituminous mix, and a steel-wheel tandem roller compacts both the reclaimed and new mix. The repaver shown in Figure 6 is designed to accomplish the complete operation of

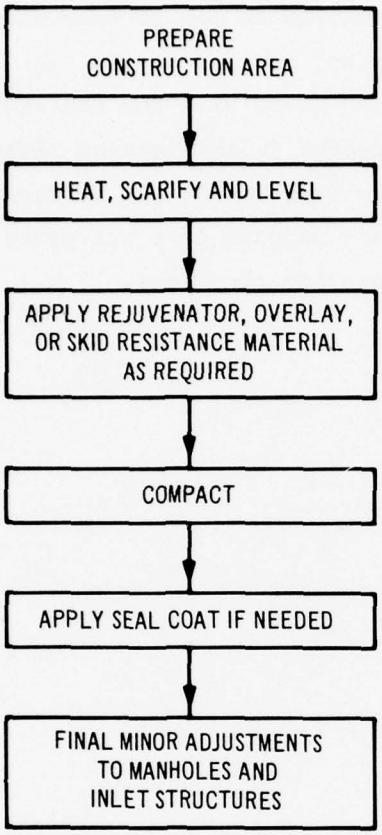

Figure 8. Process flow chart, heater-scarifier method

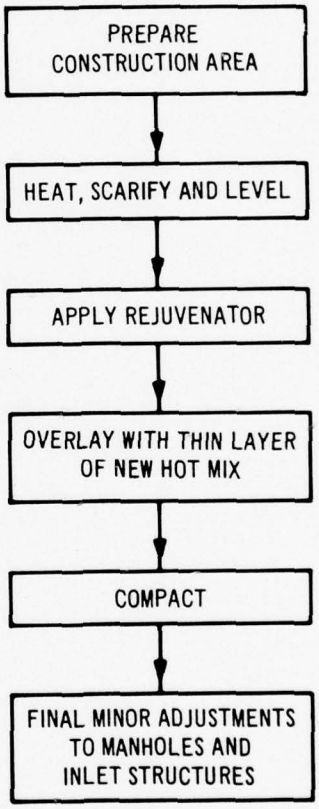

Figure 9. Process flow chart, heater-remix-overlay method

heating, scarifying, and adding a rejuvenator and overlay in one pass, thus requiring only compaction equipment to complete the process. After compaction, minor adjustments are made as required to insure adequate drainage and riding comfort. In some instances, in lieu of placing an overlay, new bituminous mix is added to and mixed with the reclaimed mix prior to screeding, or a chip seal is applied to the leveled reclaimed mix. Usually, between 8,000 and 10,000 sq yd of pavement can be repaved per day; however, the rate of repaving greatly depends upon the ambient temperature and condition of the pavement prior to treatment.

PART III: APPLICATIONS AND USES

13. The procedures and techniques reported herein are applicable for the maintenance and repair of bituminous roads, streets, parking areas, and airfields. These maintenance procedures can be used to improve the smoothness or surface defects of an existing pavement. A significant increase in the structural strength or the load-carrying capacity of pavements repaired by one of these processes is not normally obtained. Structural benefits will result only when the pavement is overlaid, and the benefit will be directly proportional to the thickness of the overlay.

Surface Defects

Crack sealing

14. Fatigue cracks and fractures can be eliminated in the top layer of a structurally sound pavement by heating and scarification.[3,4] The addition of a rejuvenator to an aged or oxidized pavement will improve the remixed layer's ability to resist fatigue and shrinkage cracking.[5] Other benefits, such as sealing of the cracks below the scarified layer with the heated remixed material, are obtained during the heating and scarification process.[3,4] The depth of treatment varies from about 1/2 to 1 in. depending upon the age, degree of oxidation, asphalt content, and gradation of the bituminous pavement.

Skid resistance

15. Bleeding or flushing of a pavement can be repaired by removing the asphalt film with a heater-planer and then adding abrasive chips as required to the heated surface. The skid resistance of a pavement that was slippery due to polished aggregate has been increased from about 35 to 55 by heating and scarifying.[4] The skid resistance of a pavement can also be restored by adding a new bituminous mix containing sharp, angular, nonpolishing aggregate to the hot scarified material during a heater-remix-overlay operation. Also, if an overlay is required, a coarser than normal and more open-graded mix can be used after heating and scarifying which will enhance skid resistance of a pavement for both wet and dry conditions.[6]

Utility trenches

16. Pavement surfaces distorted and cracked from utility repairs can be repaired by either the heater-scarifier or heater-remix-overlay procedure. During these procedures, the distortions are eliminated when hot scarified mix is leveled; the surface cracks are removed during scarification; and the deeper cracks are sealed to some extent when the hot scarified material is forced into them during compaction. Additional protection is gained for the pavement against further deterioration by applying a seal coat or a thin overlay to the compacted scarified material.

Reflective cracking

17. Reflective cracking, which is a major problem with thin overlays, is retarded when the existing surface is heated and scarified prior to the placement of an overlay. Field test results indicate that reflective cracking is significantly reduced if the pavement is heated and scarified to a depth of about 3/4 in., sprayed with a rejuvenating agent, and then overlaid with approximately 1-3/4 in. of new mix.[2] Although this type of maintenance prevents reflective cracking to a great extent, the pavements being considered for a thin overlay should be carefully investigated to determine the cause of the original distress. Placing a thin overlay over a heated and scarified surface will reduce reflective cracking provided the cracks in the original surface are not due to a structural failure.[6]

Bonding of overlays

18. The heater-remix-overlay procedure provides a good bond between the surfaces of existing bituminous material and the overlay mix. Pavements requiring overlays due to surface defects rather than structural failures can be repaired by heating and scarifying the top 3/4 in. of the existing surface and then adding between 3/4 and 1 in. of new mix to the scarified surface. This type of construction provides a positive bond between the original pavement and new mix capable of withstanding stresses applied by braking and turning of aircraft[6] such as T38's, C141's, and C-5A's. The heating and scarification of the pavement prior to overlaying burns the surface contaminants such as paint markings, rubber deposits, and fuel spills, and then mixes the residue into the pavement, thus providing a better surface for bonding an overlay or a seal coat treatment.

Reestablishment of Grades

Curbs and gutters

19. The heater-planer process is very effective where existing streets in need of repair have been overlaid once or twice before and it is impossible to meet the curb and gutter grade with additional overlays. The critical point of repairing pavements in this condition is at the curb or gutter line tie-in. If the new overlay is placed in the gutter, the flow line is raised, resulting in reduced gutter capacity; if the new surface is feathered out at the gutter edge, a good bond at that point is difficult to obtain; and if the new overlay protrudes above the gutter, the resultant trench collects debris which cannot be picked up with a mechanical sweeper. Curb lines can be restored, drainage patterns maintained, and a good bond obtained at the gutter line by planing a wedge cut about 1 in. below the lip of the gutter before placement of the new wearing surface. This procedure helps eliminate either disappearing curb lines or costly adjustments to drainage structures.

Cross section

20. By employing the heater-planer method on rutted and shoved pavements, the desired cross-sectional shapes of a pavement can be obtained. Grade problems such as buildup at the center line, feathered-out edges at the curb, and wheel path depressions are common on many pavements which have been resurfaced several times. By heating and planing pavements in the above condition prior to applying a thin overlay or seal coat, the desired cross-sectional shape can be obtained which will help restore drainage patterns and appearance.

Clearances and dead loads

21. Heater-planers are valuable for removing dead weight from bridges and for maintaining proper headroom clearances in tunnels and underpasses. Due to the additional weight or decreased clearances caused by overlays, only a limited amount of maintenance in the form of overlays can be performed on these structures before a critical point is reached, thus requiring the removal of existing material prior to placement of a new wearing surface. In these instances, a heater-planer can be utilized to remove the excessive asphaltic concrete.

Field Construction Problems

22. Several problems are associated with heater-planer, heater-scarifier, and heater-remix-overlay procedures. Some of the most common problems are discussed in the following paragraphs.

Environmental

23. Air pollution is a possible problem when asphaltic concrete pavements are heated and particles of the asphalt or surface contaminant are burned. Bushes close to the pavement and overhanging branches should be protected in some manner to prevent damage during the heating process. Vehicles and equipment parked nearby may be subject to a safety hazard due to the extremely high temperature developed during the heating process.

Rejuvenator

24. Pavements requiring rejuvenation should be tested extensively prior to treatment. Some portions of the pavement may require different amounts of a rejuvenator than others due to past maintenance. An excessive amount of a rejuvenator applied to a pavement could cause instability of the scarified layer and bleeding of the new wearing surface.

Heating and cutting

25. All dirt and loose material should be removed from the surface prior to heating. These tend to insulate the pavement and reduce the heat absorbed by the pavement. Moisture also affects the depth to which a pavement is heated. During the heating process, the heat applied should be controlled to prevent checking and charring of the surface. Difficulty in obtaining a homogeneous bond and the desired density of a new overlay can result from delaying placement and compacting the new mix on the hot scarified layer.

26. Tearing and gouging may occur during the planing process. This is usually a result of too much pressure on the cutting blade and may cause irregularities in the new wearing surface.

27. Streaking of the scarified layer could impair the appearance of the finished surface. Streaking usually results when the maximum size of the aggregate is larger than the depth scarified. The oversized aggregates are caught and pulled along by the leveling device, causing longitudinal grooves in the scarified surface.

28. Usually after the planing or scarifying operations, handwork is required to process areas around manholes and other stationary structures. These areas are generally small, and in some instances, very little handwork is required after scarification because the scarifying teeth are either spring loaded and will ride over the structure, or the teeth are mounted in such a manner that a portion of the teeth can be raised to pass over the structure, thus leaving only a few feet in width to be handworked. During a planing operation, the planing blades are raised to pass over a permanent structure; therefore, handwork is required only in an area about the width of one pass of the heater-planer and the length of the longitudinal dimension of the structure.

Advantages and Disadvantages

29. The heater-planer process removes surface irregularities and contaminated pavement surfaces, provides for better street maintenance at curb and gutter lines, improves drainage, provides for better bonding of overlays or seal coats, and reduces or eliminates leveling courses. The heater-planer operation leaves the surface of the pavement in a rough textured condition which has to be seal coated or overlaid. The cuttings removed from the pavement surface can usually be used for surfacing of areas that do not require a high quality surfacing or for base courses.

30. The chief advantage of the heater-remix-overlay process is in the combined thickness of in-place processed and added material. Less new materials are required. Use of the scarified layer (normally about 3/4 in. in thickness) and a thin overlay (3/4 to 1-1/4 in. thick) provides the equivalent of 1-1/2- to 2-in. thickness of new pavement. The heating and scarifying appear to aid in sealing shrinkage or other types of cracks and retard the reflective cracking which commonly occurs when conventional thin overlays are placed over cracked pavements. Another advantage is that a rejuvenator can be added to the scarified mix to soften the old oxidized asphalt. The chief disadvantages of the process are in not knowing what damage is done to the asphaltic binder properties in the

heating process and the effect on densities in the scarified layer. Also, the heating of the asphalt surface may create pollution problems due to the smoke created in the burning of the pavement surface.

PART IV: DESIGN

31. The primary objective of the pavement maintenance procedures reported herein is to economically repair surface defects or cross-sectional irregularities in asphaltic concrete pavements. It is of importance to realize that these procedures are not a cure for all types of pavement problems or failures. Therefore, prior to employing one of these procedures, an evaluation should be performed to determine the nature and degree of distress and the structural condition of the existing pavement. It is beyond the scope of this report to present pavement evaluation procedures. Technical Manuals in the TM 5-800 series and the Asphalt Institute's Manual MS-1 present methods for evaluating asphaltic concrete pavements. Only if the analysis of an evaluation indicates a thin overlay is required should one of these maintenance procedures be considered. Current applicable Federal or State highway specifications are recommended for the most economical use of local materials and for practices suited to the locality.

32. The application rate of a rejuvenator is critical because an excessive amount of rejuvenator will result in either a slippery surface or bond failure between the existing pavement and the new overlay or seal coat. Application rates (0.05 to 0.30 gal/sq yd) can be determined from field trial tests or laboratory testing. One field method consists of treating test patches at several application rates and observing the test patches after 24 hours. The application rate is then selected based on the amount of material entirely absorbed into the pavement within 24 hours.[7] Another similar method is Test Method No. Calif. 345-A, July 1963, "Method of Test for Determining the Quantity of Asphalt Rejuvenating Agent Required for an Asphaltic Pavement." This method consists of measuring the time required for a pavement to absorb various amounts of a rejuvenator spread within 6-in.-diam circles. The minimum application rate is that amount which will completely penetrate into the pavement in 15 minutes. Application rates can also be determined in laboratory tests by applying rejuvenators to soften oxidized asphalt. The desired application rate of a rejuvenator for a particular pavement can be determined from results

of laboratory tests performed on samples prepared from the original mix and various amounts of rejuvenator.

REFERENCES

1. "Heater/Scarifier Saves Money and Boosts Overlay Production," Highway & Heavy Construction, Jul 1976, p 90.

2. Way, George B., Prevention of Reflective Cracking in Arizona Minnetonka-East (A Case Study), Report No. 11, HPR-1-13 (224), May 1976, Arizona Department of Transportation.

3. Lynch, Edward, "Two Methods Combined to Reclaim Embrittled Asphalt," Reprint No. P 200, Jan 1964, Reprinted from Public Works Magazine, Dec 1963.

4. Johnston, T. H., "Use of Heater-Scarifier in Pavement Maintenance," Presented at the International Asphalt Paving Conference, Southampton Princess Hotel, Bermuda, Jan 1975.

5. Van Dyke, Henry, Jr., "Three-way Fix Stretches Street Maintenance Dollars," Reprint No. 1000, Apr 1975, Reprinted from American City Magazine, Feb 1975.

6. Ashley, J. F. and Nuss, D. A., "Heat-Scarifier for Pavement Maintenance," Reprint No. 1500, Jul 1975, Reprinted from The Military Engineer, Jan-Feb 1974.

7. Brown, E. R. and Johnson, R. R., "Evaluation of Rejuvenators for Bituminous Pavements," AFCEC-TR-76-3, Feb 1976, (prepared by U. S. Army Engineer Waterways Experiment Station, CE, Vicksburg, Miss.), Air Force Civil Engineer Center, Tyndall Air Force Base, Fla.

APPENDIX A

RECOMMENDED GUIDE SPECIFICATION

SECTION 2- A

HEATER-PLANER, HEATER-SCARIFIER, AND HEATER-REMIX-OVERLAY MAINTENANCE PROCEDURES FOR BITUMINOUS PAVEMENTS B

1. APPLICABLE PUBLICATIONS: The following publications of the issues listed below, but referred to thereafter by basic designation only, form a part of this specification to the extent indicated by the references thereto: C

1.1 American Society for Testing and Materials (ASTM) Publications:

D 140-70 (1976)	Sampling Bituminous Materials
D 633-74	Standard Volume Correction Table for Tar and Coal-Tar Pitch
D 977-73	Specification for Emulsified Asphalt
D 1250-56 (1973)	Petroleum Measurement Tables
D 490-47 (1968)	Specification for Tar
D 946-74	Specification for Asphalt Cement for Use in Pavement Construction
D 2028-72	Specification for Liquid Asphalt, Rapid-Curing Type

1.2 American Association of State Highway and Transportation Officials (AASHTO) Standard:

T 102-68	Spot Test of Asphaltic Materials

2. MATERIALS: Bituminous material of the following grades and consistencies shall meet the requirements as specified in the following subparagraphs. D

2.1 Bituminous Rejuvenators: Emulsified asphalts shall conform to ASTM Specification D 977 for types MS-2, SS-1, or SS-1h. The asphalt from which emulsion is made shall have a negative spot when tested in accordance with AASHTO Method T 102. E

2.2 Tack Coat: The tack coat shall be [tar][asphalt] conforming to ASTM [D 490][D 946][D 977][D 2028], type ____.

3. QUANTITIES OF MATERIALS PER SQUARE YARD: The bituminous material or rejuvenator shall be applied in quantities of not less than 0.05 nor more than 0.30 gallon per square yard. The quantities, which may be varied to meet specified field conditions at any time during the progress of the work, will be the number of gallons of material used in the accepted work.

4. EQUIPMENT, TOOLS, AND MACHINES: All equipment, tools, and machines used in the performance of the work required by this section shall be subject to approval by the Contracting Officer as determined by their effectiveness in the performance of the operations to be accomplished and shall be maintained in a satisfactory working condition at all times. All equipment used shall conform to applicable governing regulations for local air pollution controls. F

4.1 Heater-Planer: The heater-planer shall be a self-propelled machine having in combination the means of heating and planing the surface of the asphaltic concrete, and blading the cuttings into a windrow. The heating and cutting width of the machine shall be a minimum of 8 feet. The machine shall exert pressure uniformly over the surface to be cut and be able to cut flush to all curbs, inlets, manholes, or other similar obstructions within the paved area. The machine shall not rut or scuff the softened pavement surface. The machine shall be capable of working as slow as 5 fpm.

4.2 Heater-Scarifier: The heater-scarifier shall be a self-propelled machine having in combination the means of heating and scarifying the existing asphaltic concrete surface and spreading the scarified material in a uniform layer. The heating, scarifying, and spreading widths of the machine shall be the same. The machine shall be capable of producing a minimum thickness of 3/4 in. of uncompacted reclaimed mix. The machine shall not rut or scuff the softened surface of the pavement. The machine shall be capable of working as slow as 5 fpm.

4.3 Bituminous Distributor: The bituminous distributor shall have pneumatic tires of such width and number that the load produced on the surface does not exceed 650 pounds per in. of tire width. Distributors shall be designed and equipped to distribute bituminous material uniformly at even heat on various widths of surface at readily determined and controlled rates ranging from 0.05 to 2.00 gallons per square yard, with a pressure range of 25 to 75 psi. The allowable variation from any specified rate shall not exceed 5 percent. Distributor equipment shall include a separate power unit for the bitumen pump, full circulation spray bars, tachometer, pressure gages, volume measuring devices, a thermometer for

reading the temperature of tank contents, and a hose attachment suitable for applying bituminous material to inaccessible areas and patches. The distributor shall be equipped for circulation and agitation of the bituminous material during the heating process.

4.4 Power rollers shall be self-propelled, either steel-wheel or pneumatic-tired types conforming to the following requirements:

4.4.1 Steel-wheel rollers shall be of either three-wheel or tandem construction, weighing not less than 20,000 pounds each, and suitably equipped for rolling bituminous pavements.

4.4.2 Pneumatic-tired rollers shall be mounted on two axles in such manner that the rear group of wheels will not follow in the tracks of the forward group but be spaced to give uniform coverage with each pass. Axles shall be mounted in a rigid frame provided with a loading platform or body suitable for ballast loading. Tires shall be smooth and capable of being inflated to at least 90 psi. Construction of the roller shall be such that each wheel can be loaded to a minimum of 4,500 pounds.

4.4.3 Vibratory compactors may be used as approved by the Contracting Officer.

4.5 Cleaning Equipment: Brooms shall be of the self-propelled type, with a vacuum-type pickup, or towed and suitable for cleaning the surface and cracks in the existing pavement prior to treatment.

4.6 Small tools shall consist of rakes, lutes, shovels, tampers, and other tools as required.

5. WEATHER LIMITATIONS: Heater-planer or heater-remix-overlay procedures shall be performed only when the existing pavement is dry and the pavement surface temperature is above 40°F.

6. PREPARATION OF SURFACE: Immediately before heater-planer or heater-scarifier operations, the entire area to be repaired shall be cleaned of loose material, dirt, clay, paint, or other foreign material. All potholes, defective base area, utility cuts, and large cracks shall be repaired. Manhole covers, valve boxes, etc., shall be adjusted to the desired grade prior to pavement surface repair operations. G

7. PLANING OPERATION: A bituminous heater-planer shall be used to remove the existing bituminous surface of the pavement as shown on the H

drawings and specifications. The temperature at which the work is performed, the nature and condition of the equipment, and the manner of performing the work shall be such that the pavement is not torn, gouged, shoved, broken, burned, or otherwise damaged by the planing operation. Sufficient passes, or cuts, shall be made so that all irregularities or high spots are eliminated and that 100 percent of the designated surface area has been planed to the grade and cross sections specified. The asphalt and aggregate cuttings shall be removed from the site immediately after the planer passes over the pavement. No cuttings shall remain on the pavement at the end of each work day. Since high temperatures are required in the planing operation, extreme care shall be exercised against possible injury to personnel and damage to the finished surface. It shall be the responsibility of the Contractor to protect all existing structures, trees, and shrubbery from damage. Any items damaged by the Contractor shall be promptly repaired or replaced at no additional cost to the Government.

7.1 Surface Planing: Cutting below specified grades will not be permitted. The planing shall progress in a plane parallel with the desired finished grade. The planing shall proceed with care and in depth increments that will not damage the pavement below the designated finished grade. Any area damaged during the heater-planer operation shall be repaired by removing defective material and replacing with material meeting the requirements of paragraph 9. Prior to patching, all loose material shall be removed and the contact surfaces of the original pavement shall be sprayed with a thin coat of bituminous material conforming to SECTION: BITUMINOUS TACK COAT. Patched areas shall provide a surface conforming with the tolerances specified herein.

8. HEATER-SCARIFIER OPERATION: A bituminous heater-scarifier shall be used to rebuild or resurface the existing bituminous surface as required by the drawings or specifications. The temperature at which the work is performed, the nature and condition of the equipment, and the manner of performing the work shall be such that the pavement beneath that being scarified is not shoved, broken, burned, or otherwise damaged during the heating and scarifying operation. Heating shall be accomplished with a unit or units that uniformly heat the pavement to the depth to be scarified H

and hold the temperature of the scarified material to a minimum of 200°F for at least 30 seconds after the reclaimed material has been spread. The scarifier unit shall conform to the required contour of the finished pavement and spread the scarified material to the grades specified. Average depth of scarification shall create no less than 3/4 in. of reclaimed mix. The scarified pavement shall not be heated while in a loosened, scarified condition. Any area damaged during the heating-scarifying operation shall be repaired by removing damaged material, applying a thin tack coat to the contact surfaces, and replacing with satisfactory material. Patched areas shall provide a surface conforming with the tolerances specified herein. It shall be the responsibility of the Contractor to protect all existing structures, trees, and shrubbery from damage. Any items damaged by the Contractor shall be promptly repaired or replaced at no additional cost to the Government.

9. HEATER-REMIX-OVERLAY OPERATION: Immediately following the heating-scarifying operations, a ____-in. overlay of hot-mix asphaltic concrete meeting the requirements of _____ shall be layed over the hot scarified surface. The overlay pavement shall be placed with a conventional bituminous finisher following behind the heater-scarifier or by a heater-scarifier unit provided it is equipped with a receiving hopper and screed designed for placing the overlay in one pass along with the heating and scarifying operation. H,I

10. APPLICATION OF BITUMINOUS REJUVENATORS: The rejuvenating material shall be applied with a bituminous distributor or other approved equipment at a temperature of 75 to 130°F as directed. The rejuvenating material shall be applied at a pressure within the range of 25 to 75 psi and in such manner that distribution is uniform. Spots unavoidably missed shall be properly treated. During construction, the application rate shall be adjusted by the Contracting Officer if necessary to suit field conditions. J

11. COMPACTION OF PLANED SURFACES: At the completion of planing and patching, if required, the heater-planer shall immediately go over the planed area, heating but not cutting the asphalt surface, followed immediately by the application of a bituminous fog coat and pneumatic rollers to densify materials loosened by the planer operation as specified hereinafter. The treated area shall receive a minimum of six passes and until

all roller marks are eliminated. The bituminous fog coat shall be applied in accordance with SECTION: BITUMINOUS TACK COAT. If weather conditions will not permit immediate application of fog coat and rolling, the planed area shall be rolled with two passes of an approved roller to temporarily seal the area. When weather conditions permit, the Contractor shall dry, reheat, apply fog coat, and roll the area. The use of temporary rolling shall be at no additional cost to the Government.

12. COMPACTION OF SCARIFIED SURFACES: Compaction shall begin as soon as the remixed mixture will bear the roller without undue displacement. Initial rolling shall be accomplished by applying two passes of a 10-ton steel-wheel roller. After initial rolling, preliminary tests of crown, grade, and smoothness shall be made by the Contractor. Before final rolling, deficiencies shall be corrected so that the finished course will conform to requirements for grade and smoothness specified herein. Final compaction shall be accomplished by applying six passes with a pneumatic-tired, self-propelled roller. Places inaccessible to rollers shall be thoroughly compacted with hand tampers. All joints shall have the same texture, density, and smoothness as other sections of the repaired pavement.

13. COMPACTION OF REMIXED-OVERLAYED SURFACES: Compaction of the overlay mixture shall begin as soon after placing as the mixture will bear the roller without undue displacement. After initial rolling, preliminary tests for crown, grade, and smoothness shall be made by the Contractor and any deficiencies shall be corrected so that the finished course will conform to the requirements for grade and smoothness specified below. After preliminary smoothness tests, rolling shall continue until a density is obtained in the overlay mixture that is not less than ____ percent of the density of laboratory-compacted specimens of the same mixture. K

14. GRADE AND SURFACE SMOOTHNESS REQUIREMENTS: The finished surface shall conform to gradeline and elevations shown and to surface smoothness requirements specified below.

14.1 Plan Grade: Finished surfaces shall conform to the lines, grades, and cross sections indicated, or to elevations established and approved

at site of work. Finished surfaces at junctures with other pavements shall coincide with finished surfaces of abutting pavements.

14.2 Surface Smoothness: Finished surfaces shall not deviate from the testing edge of a 10-ft straightedge more than 1/4 in. in the transverse or longitudinal direction.

15. *DEBRIS REMOVAL: Immediately upon completion of [planing, scarifying]* operation in any area, all cuttings, loosened materials, and debris shall be removed from the area and disposed of in the designated disposal area. Failure to keep the pavement surface in a clean condition may result in a shutdown of work until cleaning is satisfactory to the Contracting Officer. L

16. SAMPLING AND TESTING:

16.1 Sampling: *All samples of bituminous material, unless otherwise* specified, shall be in accordance with the requirements of ASTM D 140. All materials will be subject to approval prior to use. Samples of proper size shall be submitted for approval not less than ____ days before *commencing the work.*

16.1.1 Samples of compacted overlay pavements shall be obtained for density determinations. The type, size, number, and location of samples shall be as directed by *the Contracting Officer. A power saw or core* drill shall be used for cutting the in-place pavement samples. The Contractor shall furnish all tools, labor, and materials for cutting samples and for backfilling test holes to the satisfaction of the Contracting Officer.

16.2 Testing: Testing will be the responsibility of the [Contractor] [Government] and shall be performed by an acceptable commercial testing laboratory or by the *Contractor on the approval of the Contracting Officer.* The materials shall be tested to establish compliance with the specified requirements. Copies of test results shall be furnished to the Contracting Officer.

17. METHODS OF MEASUREMENT: Measurement for payment of the bituminous material, rejuvenator, and area of pavement repaired will be the measured quantities used in the accepted work as determined by the following methods: M

17.1 Bituminous Material and Rejuvenator: The quantity of rejuvenating and bituminous material to be paid for shall be the number of gallons used in the accepted work as determined by the Contracting Officer, corrected to gallons at 60°F in accordance with ASTM [D 1250, D 633], using a coefficient of expansion of 0.00025 per °F for asphalt emulsion.

17.2 Heater-Planing or Heater-Scarifying: The quantity of heater-planing or heater-scarifying of bituminous concrete surfaces shall be the number of square yards completed and accepted as determined by the Contracting Officer. Measurements will be along the surface of the pavement.

17.3 Asphaltic Concrete: The quantity of asphaltic concrete to be paid for will be the number of 2000-pound tons of asphaltic concrete used in the accepted work. Asphaltic concrete will be weighed after mixing, and no deductions will be made for weight of bituminous material incorporated therein. No payment will be made for defective areas until corrected.

GENERAL NOTES

1. This guide specification is part of a series of Federal Construction Guide Specifications, which are being established to promote greater uniformity in construction specifications for Federal construction. Use of this guide specification in whole or in part by Federal agencies is encouraged.
2. The capital letters in the right-hand margins indicate that there is a technical note pertaining to that portion of the guide specification. It is intended that the letters in the margins be deleted before typing the project specifications.
3. Where numbers, symbols, words, phrases, clauses, or sentences in this specification are enclosed in brackets [], a choice or modification must be made; delete inapplicable portion(s). Where blank spaces occur in sentences, insert the appropriate data. Where entire paragraphs are not applicable, they should be deleted completely.

A. The section number should be inserted in the specification heading and prefixed to each page number in the project specification.

B. This specification includes materials, construction procedures, equipment, and testing requirements for heater-planer, heater-scarifier, and heater-remix-overlay procedures for bituminous pavements. Heater-planers have been valuable for many years for removing dead weight from bridges, maintaining proper headroom clearance in tunnels and underpasses, and removal of surface irregularities from rough asphalt pavements. Recent developments in heater-planing and scarifying equipment, rising costs, and the energy crisis have made these procedures more advantageous for the repair and maintenance of old asphalt pavements. Also, due to these developments and circumstances, equipment is now available which has the capability to handle large projects such as highways and airports. Experience and data indicate that planing and repaving operations are feasible only on existing asphaltic concrete pavements which are structurally sound but in need of surface leveling or sealing; for example, pavements disturbed for utility trenches or other openings or where patches have settled and surface deterioration exists. Curb lines can be restored and drainage patterns maintained by planing off a portion of the existing surface before the application of a new wearing surface. This eliminates either disappearing curb lines or costly procedures to adjust drainage structures. The heater-remix-overlay method permits the engineer in many instances to select a much thinner overlay by eliminating bonding problems between the surfaces of the existing bituminous material and the overlay mix. Reflective cracking, which is a major problem with thin overlays, is somewhat retarded when the existing surface is heated and scarified prior to the placement of an overlay. Reflective cracking does appear in the new surface but at a slower rate and is not as severe as with a conventional thin overlay. Skid resistance and bleeding or flushing asphalt can be improved by use of a heater-planer to remove the excess asphalt or by adding abrasive chips to a heated

scarified surface. These types of maintenance techniques are also applicable to airfield pavements because surface contaminants such as rubber, paint, oil, and fuel deposits are burnt off during the heating process. Removal of these contaminants helps in preventing slippage between thin overlays or seal treatments and the old pavement surface. It is the intent of these specifications to give guidance in the use of heater-planers or heater-scarifiers for the maintenance of bituminous pavements. Additional thickness requirements or seal coats should be accomplished by conventional procedures according to their respective specifications.

C. Paragraph 1: The listed designations for publications are those that were in effect when this guide specification was being prepared. Designations that are known to be out of date when project specifications are prepared should be changed to those current at that time, and the nomenclature, types, grades, classes, etc., referenced in the guide should be checked for conformance to the latest revision or amendments. To minimize the possibility of error, the letter suffixes, amendments, and dates indicating specific issues should be retained here and omitted elsewhere in the project specifications.

D. Paragraph 2: The materials to be allowed will be retained in the contract specifications, and the remaining subparagraphs will be deleted.

E. Paragraph 2.1: The requirements for type SS-1h asphalt emulsion are the same as for type SS-1 using the test procedure of ASTM Specification D 244, "Testing Emulsified Asphalts," except the penetration of the residue at 77°F is specified to be 40 to 90 rather than 100 to 200. Grade SS-1 asphalt emulsion should be specified in moderate or cold climates. Grade SS-1h should be specified in hotter climates such as the southern or southwestern areas of the United States. The inapplicable grade will be deleted. Paxole, Reclamite, or other patented products for use as a bituminous rejuvenator may be specified in the contract documents provided proof of satisfactory performance for rejuvenating oxidized asphaltic concrete pavements is obtained.

F. Paragraph 4: Equipment required will be retained in the contract specifications, and the remaining subparagraphs will be deleted.

G. Paragraph 6: If the surface to be treated contains utility accesses, drainage systems, etc., that require repairs, the method of repairs and extent of work involved should be shown on plans and described in a separate section of the specifications.

H. Paragraph 7: The amount of heat applied to the pavement shall be controlled so that the heated pavement is not checked, charred, or otherwise damaged. The scarified pavement shall not be heated while in a loosened, scarified condition. Experience has indicated that loose material on the surface tends to insulate the pavement, and thus there is less heat absorbed by the pavement. For heater-planer operations, multiple passes of the burner may be required to obtain the desired depth of cut but will be allowed only when the cuttings have been removed.

   Excess heat will burn the asphalt binder; however, sufficient heat should be applied to hold the temperature of the scarified material to a minimum of 200°F prior to compaction or to the application of a thin overlay.

I. Paragraph 9: State or other local highway construction agency job-mix formula specifications may be incorporated in the contract documents for manufacturing the central-plant hot mix.

J. Paragraph 10: It is recommended that the rejuvenator be added after the heating process.

K. Paragraph 13: The blank will be filled in to agree with density requirements specified for the job-mix formula selected.

L. Paragraph 15: This paragraph will be deleted when this specification is to be used for pavement maintenance other than airfields.

M. Paragraph 17: When other methods of measurement are desired or necessary, the paragraph will be modified accordingly.

In accordance with ER 70-2-3, paragraph 6c(1)(b), dated 15 February 1973, a facsimile catalog card in Library of Congress format is reproduced below.

Grau, Robert Walter

Heater-planer, heater-scarifier, and heater-remix-overlay maintenance procedures for bituminous pavements, by Robert W. Grau. Vicksburg, U. S. Army Engineer Waterways Experiment Station, 1977.

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